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US-CL-CURRENT: 29/868

ABSTRACT:

An electrically conductive (64) brush is used for redistributing the residual toner images over imaging surface (10) so that the toner can be more effectively removed from the surface by the developer system C. The brush is moved in a direction perpendicular to the direction of movement (16) of the photoconductive surface and is electrically biased by means of an A.C. voltage (66) such that not only is the toner dislodged it is also picked up by the brush from one area of the photoconductive surface and dropped it on another area. By proper selection of the A.C. and D.C. voltages the conductive brush can be simultaneously used for redistribution and uniformly charging the photoreceptor surface. The perpendicular movement may be by reciprocation of a brush as shown, or by rotation of a cylindrical brush with a helical array of bristles. <IMAGE>

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GB 1376740
US 4361922
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## (54) Cleaning photoconductors

(57) An electrically conductive (64) brush is used for redistributing the residual toner images over imaging surface (10) so that the toner can be more effectively removed from the surface by the developer system C. The brush is moved in a direction perpendicular to the direction of movement (16) of the photoconductive surface and is electrically biased by means of an A.C. voltage (66) such that not only is the toner dislodged it is also picked up by the brush from one area of the photoconductive surface and dropped it on another area. By proper selection of the A.C. and D.C. voltages the conductive brush can be simultaneously used for redistribution and uniformly charging the photoreceptor surface. The perpendicular movement may b by reciprocation of a brush as shown, or by rotation of a cylindrical brush with a helical array of bristles.

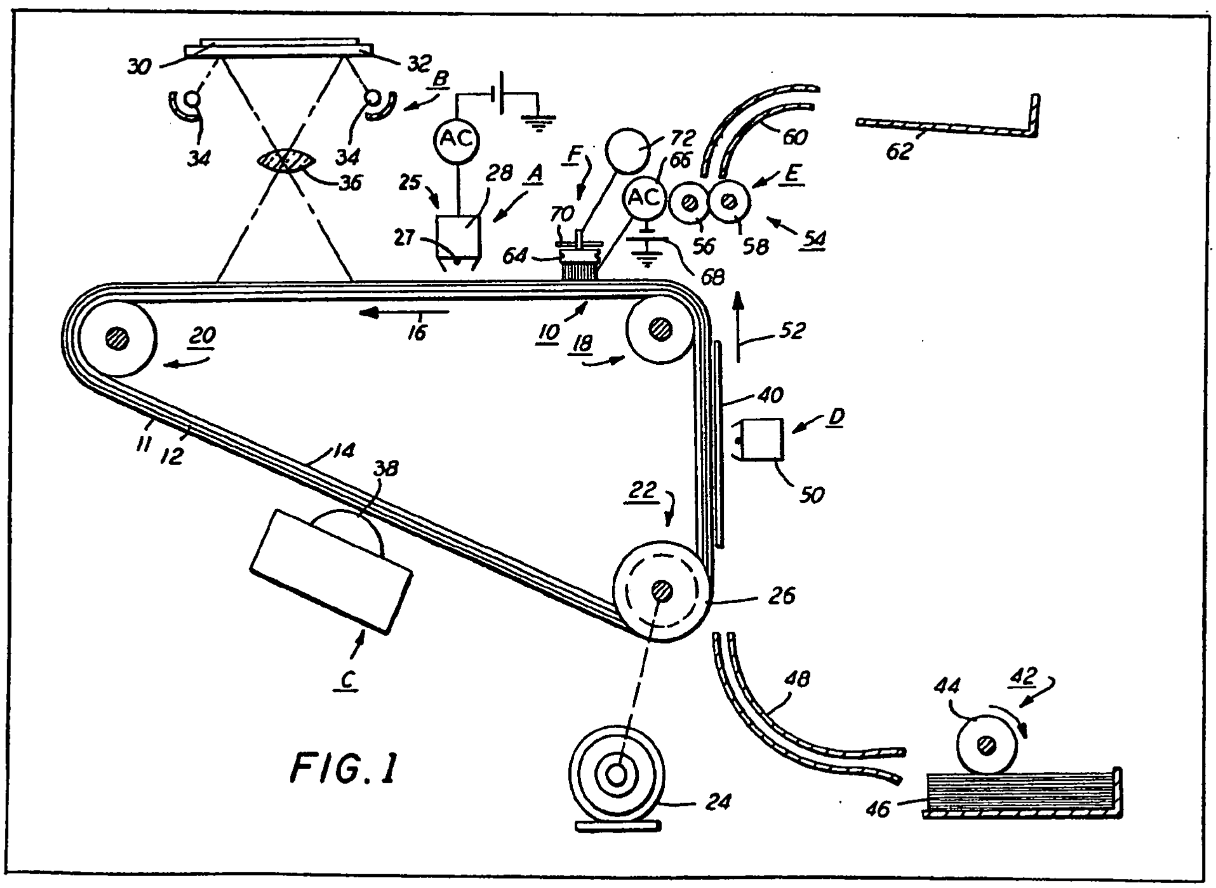


FIG. 1

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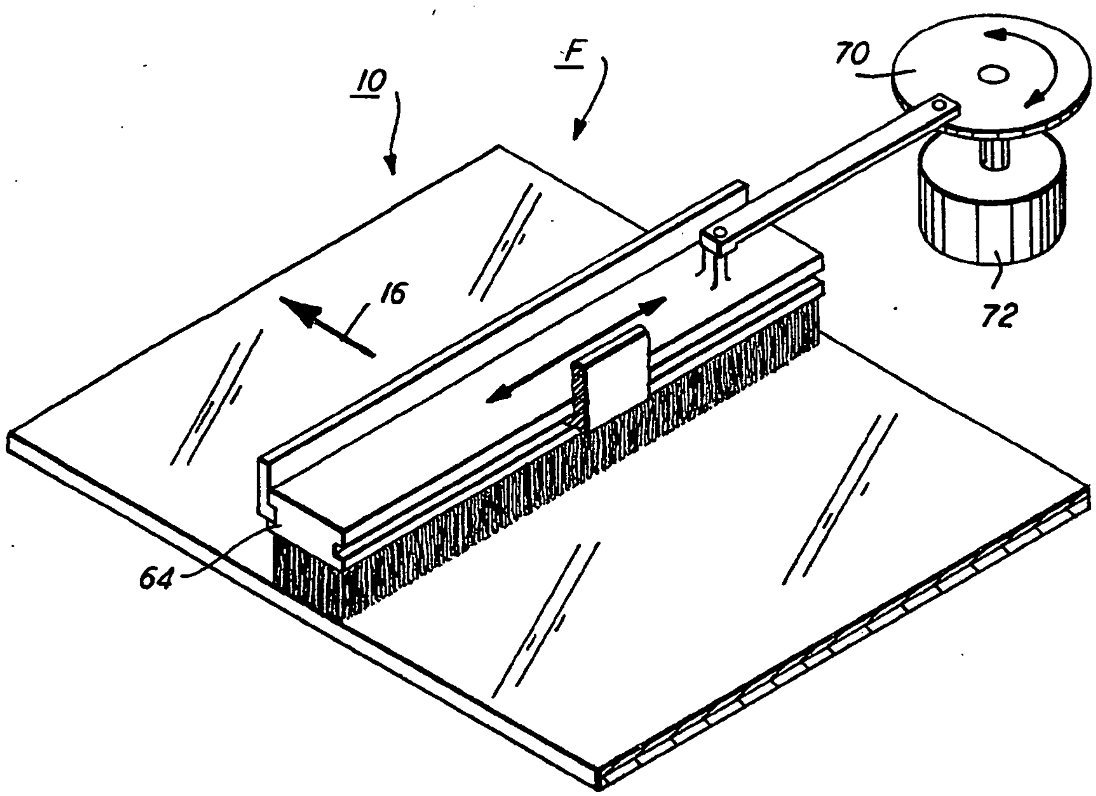
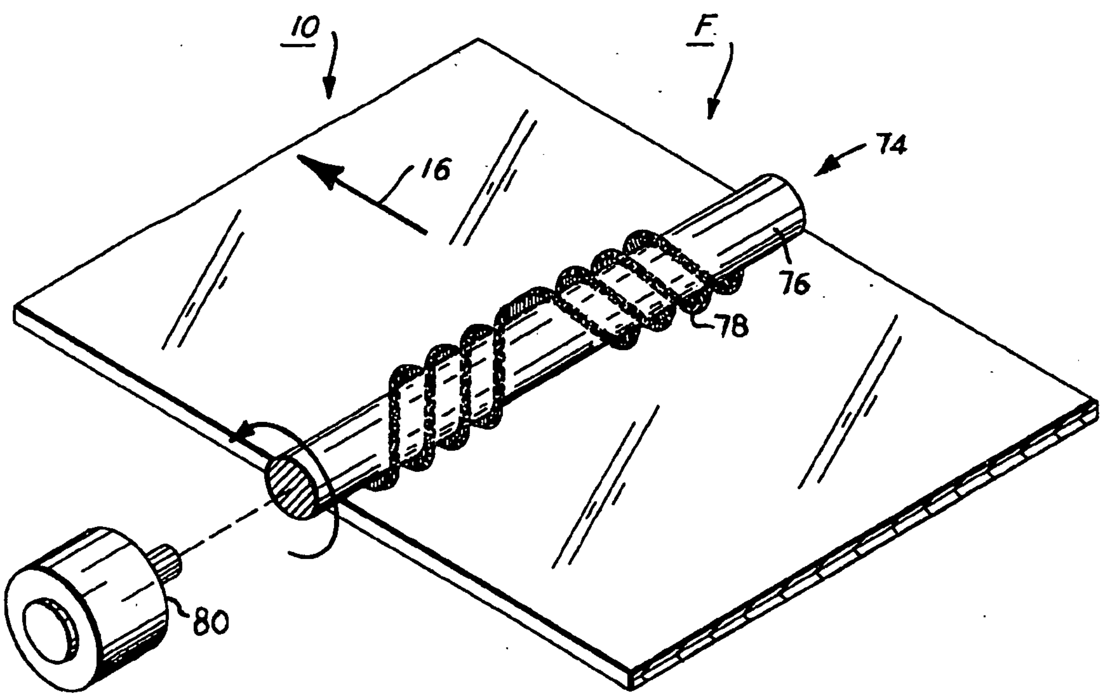
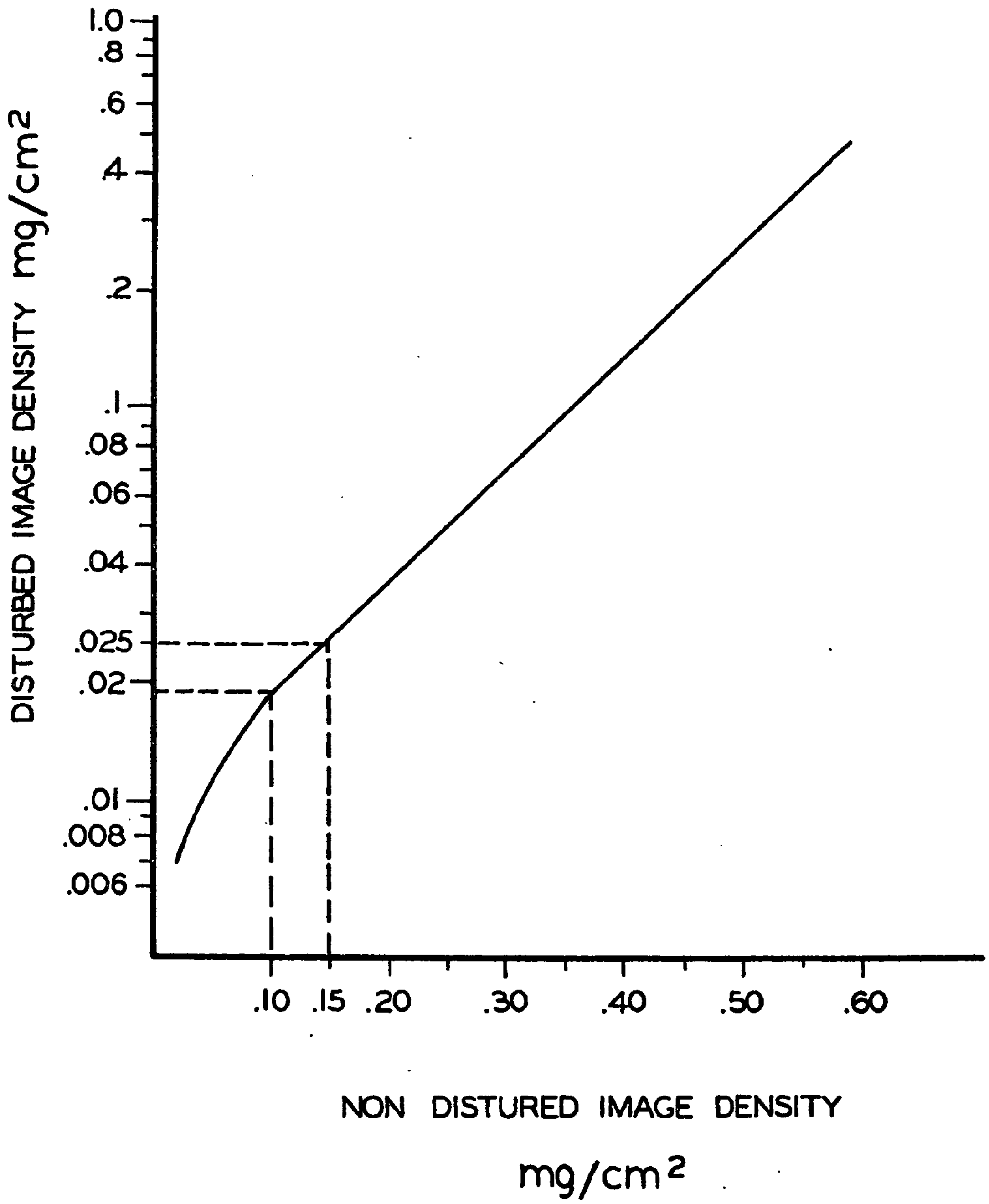



FIG. 2

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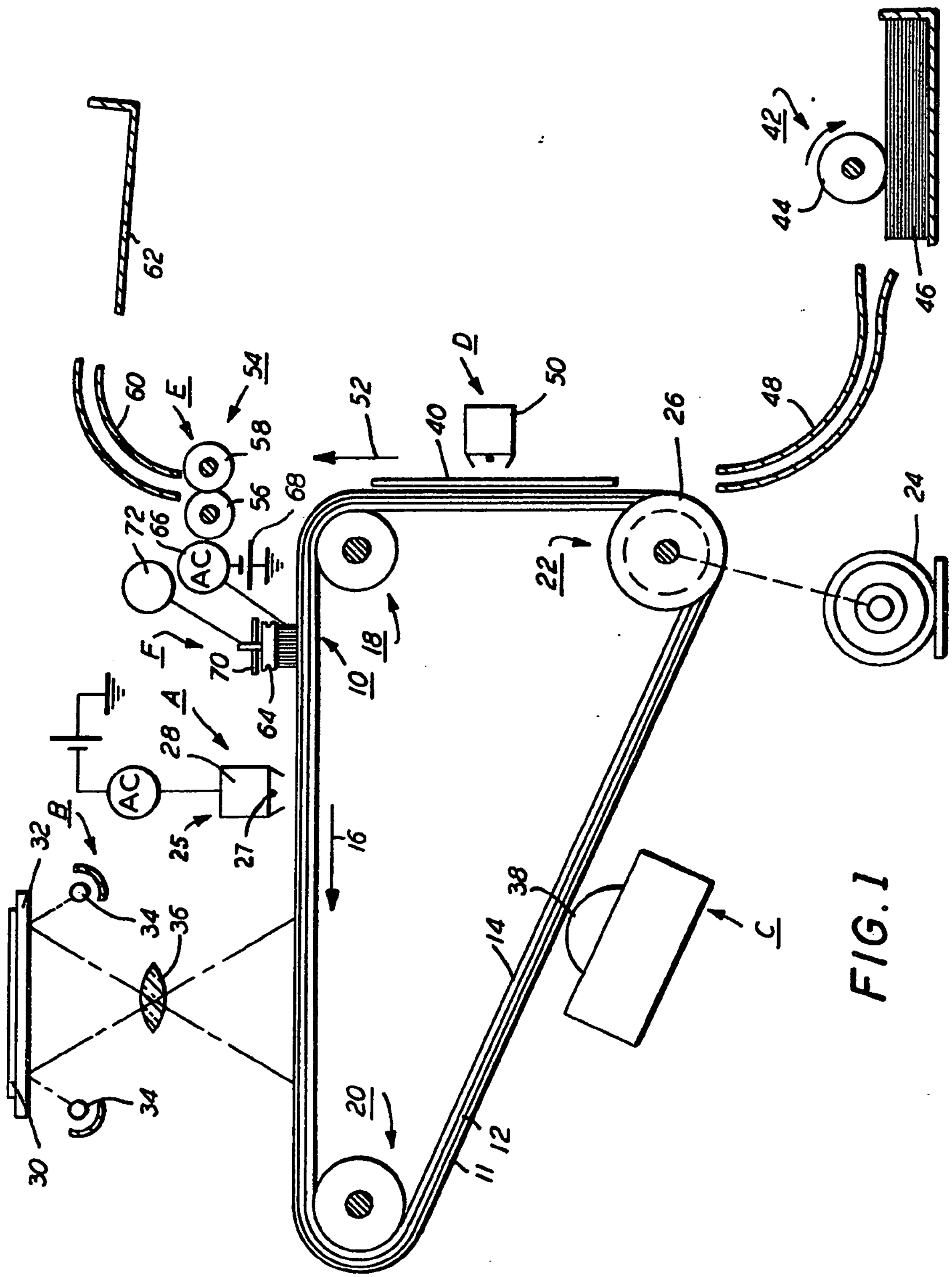
DISTURBED IMAGE DENSITY mg/cm2
.10
.15
.20
.30
.40
.50
.60
NON DISTURED IMAGE DENSITY
mg/cm2

FIG. 3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72
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D
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F
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AC

FIG. 1

SPECIFICATION

**Cl aning m thod and apparatus f r a xerographic r producing apparatus**

This invention relates to the art of xerography and, in particular, to a method and apparatus for removing residual toner material from the photoconductor surface of an automatic xerographic reproducing apparatus wherein development of the latent image and removal of residual toner are effected at a single station by the same structure.

In the art of xerography, a plate generally comprising a photoconductive insulating material adhered to a conductive backing is charged uniformly. Then, the uniformly charged plate is exposed to a light image of an original document to be reproduced. The latent electrostatic images, thus formed, are rendered visible by applying any one of numerous pigmented resins specifically designed for this purpose. In the case of a reusable photoconductor, the pigmented resin, more commonly referred to as toner, which forms the visible images is transferred to plain paper.

Although a preponderance of the toner forming the images is transferred to the paper during transfer, some toner remains on the photoconductor surface, it being held thereto by relatively high electrostatic and/or mechanical forces. It is essential for optimum operation that the toner remaining on the surface be cleaned therefrom.

A commercially successful mode of cleaning employed in automatic xerography utilizes a brush with soft bristles which have suitable triboelectric characteristics. While the bristles are soft they are sufficiently firm to remove residual toner particles from the xerographic plate. In addition, webs or belts of soft fibrous or tacky materials and other cleaning systems are known. The foregoing types of cleaning devices require structure that is designed solely for the purpose of cleaning and require a certain amount of space contiguous the photoconductor.

In spite of the successes that have been achieved in removing residual toner from photoconductor surfaces there is still room for improvement. This is especially true in xerographic systems where the development and cleaning functions are effected at a single process station by the same structure. Such an arrangement is found in U.S. Patent No. 3,649,262 wherein apparatus is disclosed for removing residual toner images from a photoconductor surface simultaneously with the development of newly formed latent electrostatic images. In a simultaneous system such as disclosed in the foregoing patent, a separate cleaning structure is not utiliz d since the two component (i.e. carrier beads and toner) developer which is cascaded over the ph toconductor surface during dev lopment is used for cleaning the residual toner therefrom. As stated in the patent, the residual images are remov d by combinations of mechanical, triboelectric and electrostatic actions of the cascading developer.

Further efforts to improve upon the cleaning concept of the '262 patent as illustrated in U.S. Patent No. 3,617,123 utilized a vibrating brush as an adjunct to the cleaning effected by the developer system. There the vibrating brush is positioned upstream from the point where the photoconductor drum surface enters a combination development and cleaning station which is functionally similar to that disclosed in the '262 patent. The brush is mounted longitudinally along the drum surface so that the brush fibers are in light touching contact with the surface to be cleaned and is vibrated transversely across the drum surface. Thus, the brush serv s to reposition or puddle the charged residual toner particles over the drum so that they can be more readily removed by the combination development and cleaning system. While the material from which the brush fibers is fabricated is not specified, it is clear from the patent disclosure that the material is electrically insulative otherwise it would act as a conductive path allowing at least some of the latent images on the drum to be dissipated. A brush of this type physically dislodges the built-up residual toner and tends to spread it over the imaging surface. However, after periods of extended use the toner becomes impregnated in the bristles of the brush resulting in the brush becoming ineffective for its intended purpose.

According to the present invention, there is provided an apparatus for removing residual ton r from a photoconductor, said apparatus comprising means for presenting toner material to the surface of said photoconductor as said photoconductor is moved therepast to thereby develop a toner image thereon; a conductive brush mounted for movement relative movement relative to said photoconductor and in contact therewith; means for effecting said movement of said conductive brush; and means for applying a voltage to said conductive brush to thereby alternately cause attraction and repulsion of toner to the brush bristles whereby toner is dislodged and picked up from areas of the photoconductor and deposited on other areas.

In a preferred embodiment of the invention the foregoing is accomplished by applying an A.C. voltage to the conductive brush which voltag has a D.C. bias applied thereto. In this manner positive toner will be attracted to or picked up by the bristles during the negative half cycle of the A.C. voltage and repelled or dropped back on to the photoconductor on the negative half-cycle thereof. In a like manner, negative toner will be pick d up during the positive half cycle and dropped during the n gative half cycle. By th provision of the foregoing brush utilized in the described manner, removal of the residual toner by the developing system is facilitated to a higher degree than heretofore possible with prior art configurations. The conductive brush operated in the described manner serves to change non-uniform, high-density residual images that are not cleanable by

the development system to substantially uniform, low-d nsity imag s which are cl anabl . By selection of suitable A.C. and D.C. voltages the conductive brush also serv s to uniformly charge the photoreceptor so that it is ready for the next imaging cycle.

Other aspects of the present invention will become apparent as the following description proceeds with reference to the drawings, in which:

Figure 1 is a schematic elevational view depicting an electrophotographic printing machine incorporating the present invention;

Figure 2 is a fragmentary perspective view illustrating an embodiment of a conductive brush utilized in the machine of Figure 1;

Figure 3 is a plot of disturbed image density versus corresponding non-disturbed image density for residual toner images; and

Figure 4 is a fragmentary perspective view illustrating another embodiment of a conductive brush utilized in the machine of Figure 1.

For a general understanding of the features of the present invention, a description thereof will be made with reference to the drawings. In the drawings, like reference numerals have been used throughout to designate identical elements. Figure 1 schematically depicts the various components of an illustrative electrophotographic printing machine incorporating the apparatus and method of the present invention therein.

Inasmuch as the art of electrophotographic printing is well known, the various processing stations employed in the printing machine illustrated in Figure 1 will be described only briefly.

As shown in Figure 1, the printing machine utilizes a photoconductive belt 10 which consists of an electrically conductive substrate 11, a charge generator layer 12 comprising photoconductive particles randomly dispersed in an electrically insulating organic resin and a charge transport layer 14 comprising a transparent electrically inactive polycarbonate resin having dissolved therein one or more diamines. A photoreceptor of this type is disclosed in U.S. Patent No. 4,265,990. Belt 10 moves in the direction of arrow 16 to advance successive portions thereof sequentially through the various processing stations disposed about the path of movement thereof. Belt 10 is entrained about stripping roller 18, tension roller 20, and drive roller 22. Drive roller 22 is mounted rotatably and in engagement with belt 10. Motor 24 rotates roller 22 to advance belt 10 in the direction of arrow 16. Roller 22 is coupled to motor 24 by suitable means such as a belt drive.

Belt 10 is maintained in tension by a pair of springs (not shown) resiliently urging tension roll r 20 against b lt 10 with the desir d spring force. Both stripping roller 18 and tension roller 20 ar rotatably mounted. Thes rollers are idlers which rotate freely as belt 10 moves in the direction of arrow 16.

With continued reference to Figure 1, initially a portion of belt 10 passes through charging station A. At charging station A, a corona device, indicated generally by the ref r nce numeral 25, charges charge generator lay r 12 f b lt 10 to a relatively high, substantially uniform negative potential. A suitable corona generating device for negatively charging the photoconductive belt 10 comprises a conductive shield 28 and corona wire 27 the latter of which is coated with an electrically insulating layer having a thickness which precludes a net D.C. corona current when an A.C. voltage is applied to the corona wire and when the shield and the photoconductive surface are at the same potential.

Next, the charged portion of photoconductive belt is advanced through exposure station B. At exposure station B, an original document 30 is positioned facedown upon transparent platen 32. Lamps 34 flash light rays onto original document 30. The light rays reflected from original document 30 light images which are transmitted through lens 36. The light images are projected onto the charged portion of the photoconductive belt to selectively dissipate the charge thereon. This records an electrostatic latent image on the belt which corresponds to the informational area contained within original document 30.

Thereafter, belt 10 advances the electrostatic latent image to development station C. At development station C, a magnetic brush developer roller 38 advances a developer mix (i.e. toner and carrier granules) into contact with the electrostatic latent image. The latent image attracts the toner particles from the carrier granules thereby forming toner powder images on the photoconductive belt.

Belt 10 then advances the toner powder image to transfer station D. At transfer station D, a sheet of support material 40 is moved into contact with the toner powder images. The sheet of support material is advanced to transfer station D by a sheet feeding apparatus 42. Preferably, sheet feeding apparatus 42 includes a feed roll 44 contacting the upper sheet of stack 46. Feed roll 44 rotates so as to advance the uppermost sheet from stack 46 into chute 48. Chute 48 directs the advancing sheet of support material into contact with the belt 10 in a timed sequence so that the toner powder image developed thereon contacts the advancing sheet of support material at transfer station D.

Transfer station D includes a corona generating device 50 which sprays ions of a suitable polarity onto the backside of sheet 40 so that the toner powder images are attracted from photoconductive belt 10 to sheet 40. After transfer, the sheet continues to move in the direction of arrow 52 onto a conveyor (not shown) which advanc s the sheet to fusing station E.

Fusing station E includes a fuser assembly, indicated generally by the reference numeral 54, which permanently affixes the transferr d toner powder images to sheet 40. Preferably, fuser assembly 54 includes a heated fuser roller 56 adapted to be pressure engaged with a back-up roller 58. Sheet 40 passes between fuser roller 56 and back-up roller 58 with th toner powder

images contacting fuser roller 56. In this manner, the toner powd r imag is permanently affixed to sheet 40. After fusing, chute 60 guid s th advancing sheet 40 to catch tray 62 for removal from the printing machine by the operator.

At an image disturbing station F there is provided an electrically conductive brush 64 to which an A.C. voltage is supplied from a source 66. A D.C. bias 68 is applied to the A.C. source 66. The brush is adapted to be cyclically moved in a direction substantially perpendicular to the direction of movement of the photoconductive belt 10. Such movement may be accomplished by means of a cam structure 70 operatively connected to a motor 72.

In one operative embodiment, the A.C. voltage was 1500 volts at 250 Hz and the D.C. bias voltage was equal to a negative 250 volts while the mechanical frequency of the brush was 1800 cycles per minute. With a brush to belt interference of 2.54 mm it is desirable for optimum results that the relative speed between the belt and brush is such as to permit the brush to make two complete oscillations during the time a point on the photoconductive belt moves through the nip (i.e. area of contact between the brush and belt) formed between the brush and the belt. Such a device has been used effectively with insulative toner, both magnetic and non-magnetic.

The optimum A.C. frequency for process speeds in the range from 12.7 to 25.4 cm/sec is 250 Hz. Lower A.C. frequencies can be used for slower process speeds (<12.7 cm/sec) and higher A.C. frequencies for process speeds >25.4 cm/sec. Thus, the A.C. frequency may range from 120 to 300 Hz depending on the process speed. The A.C. peak-to-peak voltage may vary from 1000 to 2000 volts for effective disturbing. The bias voltage depends on the polarity of the input toner charge density to the disturber and also to whether the brush is to be used simultaneously for charging the photoreceptor to a uniform charge. For example, if the input toner charge density is positive, then the D.C. bias is negative in the range from −100 to −400 volts. The optimum bias voltage depends on the A.C. voltage. For example, for 1500 VAC the optimum D.C. bias for disturbing only is −250 volts for positive toner. When simultaneous disturbing and charging are to be accomplished the D.C. bias can be a negative 900 volts at 200 Hz when the A.C. voltage is 1200 volts.

The electrically conductive brush 64 comprises conductive fibers of steel, carbon coated nylon, carbon or graphite. The density of the fibers which have a diameter in the order of 10—60 $\mu$ and a resistivity of $10^{-6}$ to $10^{6}$ ohm-cm is in the order of 2.3 to 9.3 K/cm$^2$.

During operation of the brush structure of the present invention, the toner forming the residual images remaining on the photoconductive belt aft r the transfer step is redistributed such that it can be removed by the magnetic brush developer roller 38 as the redistributed toner moves through the development station C.

In studies conducted with the arrangement depicted in Figure 1, without the use of the conductive brush 64 it was found that the developer roll 38 could ff ctively remove non-disturbed residual toner having a mass density less than 0.01 mg/cm$^2$. However, it was found quite unexpectedly that when the brush 64 was used in the manner described the developer roll 38 could remove disturbed residual toner having a mass density of 0.025 mg/cm$^2$.

Figure 3 represents a plot of disturbed image density versus non-disturbed image density. As can be seen from the curve of Figure 2 a mass density of 0.025 mg/cm$^2$ for disturbed images corresponds to a non-disturbed mass density of 0.15 mg/cm$^2$. This means that since the developer roll 38 can effectively remove disturbed toner with a mass density of 0.025 mg/cm$^2$ then the mass density of the undisturbed toner just after transf r can be 0.15 mg/cm$^2$. Typically, in a system such as the one depicted in Figure 1 the mass density of the undisturbed images just after transfer is 0.1 mg/cm$^2$. Accordingly, the roller 38 is effective in removing the residual toner.

As shown in Figure 4 a modified conductive brush 74 is employed for disturbing the residual images. The brush 74 comprises a cylindrical base 76 with the brush fibers 78 attached thereto arranged in the shape of a double helix designed to dislodge the residual toner towards the center of the belt. This arrangement minimizes the buildup of toner on the edge of the belt. The brush is preferably rotated by a motor 80 at angular velocity such that the brush makes at least 0.5 revolution during the time a point on the belt moves through the brush nip. The fiber interference with the belt is the same as in the previously described embodiment. Voltage may be applied to the brush 74 by means of slip rings (not shown).

The conductive brush image disturbers of th present invention have been used with insulative magnetic toner as well as insulative, non-magnetic toner. A preferred toner is disclosed in Example 1 of U.S. Patent No. 4,298,672. Other suitable toners are disclosed in this patent.

CLAIMS

1. Method of removing residual toner from a photoconductor, comprising

presenting toner material to the surface of said photoconductor as said photoconductor is mov d therepast to thereby develop a toner image thereon,

moving a conductive brush which contacts said photoconductor relative to said photoconductor, and

applying a voltage to said conductive brush to thereby alternately cause attraction and repulsion of toner to the brush bristles whereby toner is dislodged and picked up from areas of the photoconductor and deposit d in other ar as.

2. Method of making xerographic copies, said method including the toner removal method of Claim 1, and comprising the steps of:

moving a photoconductor along an endless path;

uniformly charging said photoconductor;

exposing said photoconductor to a light image to thereby form a latent electrostatic image thereon;

applying toner material at a developing station to said latent image to thereby produce a visible image;

transferring said visible image from said photoconductor;

moving a conductive brush which contacts said photoconductor in a direction generally perpendicular to the direction of movement of said photoconductor and simultaneously applying an electrical bias to said conductive brush whereby toner material forming residual images on said photoconductor is redistributed on the photoconductor such that the mass density thereof is low enough to enable the residual toner to be removed at said developing station; and

removing said residual developer at said developing station.

3. Apparatus for removing residual toner from a photoconductor, said apparatus comprising:

means for presenting toner material to the surface of said photoconductor as said photoconductor is moved therepast to thereby develop a toner image thereon;

a conductive brush mounted for movement relative movement relative to said photoconductor and in contact therewith;

means for effecting said movement of said conductive brush; and

means for applying a voltage to said conductive brush to thereby alternately cause attraction and repulsion of toner to the brush bristles whereby toner is dislodged and picked up from areas of the photoconductor and deposited on other areas.

4. Apparatus according to Claim 3 wherein said brush is reciprocated two complete oscillations during the time a point on the photoconductor moves through the nip formed between the brush and the photoconductor.

5. Apparatus according to Claim 3 or Claim 4 wherein said voltage is an A.C. voltage of 1500 volts at 250 Hz with a D.C. bias equal to a negative 250 volts.

6. Apparatus according to Claim 3 wherein said brush is supported for rotation and comprises fibers arranged in the shape of a double helix such that toner is moved toward the center of the photoconductor.

7. Apparatus according to Claim 6, including means for rotating said brush such that it makes at least 0.5 revolution during the time a point on the photoconductor moves through the nip formed between said brush and said photoconductor.

8. Apparatus according to any one of Claims 3 to 7 wherein said voltage is an A.C. voltage between 1000—2000 volts at 120 to 300 Hz with a D.C. bias of 100 to 900 volts to thereby uniformly charge said photoconductor.

9. Method of removing residual toner from a photoconductor substantially as hereinbefore described with reference to the accompanying drawings.

10. Apparatus for removing residual toner from a photoconductor substantially as hereinbefore described with reference to the accompanying drawings.

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